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INFLUENCE OF WIDE ROW SPACINGS AND INTERCROPS ON SUGARCANE GROWTH, YIELD AND JUICE QUALITY UNDER DRIP IRRIGATION IN NORTH-WEST KARNATAKA

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ABSTRACT

A field experiment was conducted at KIAAR Sameerwadi, Tal: Mudhol, Dist: Bagalkot, Karnataka during 2013-14, to study the effect of different wider row spacings and intercrops on growth, yield and quality of sugarcane. The experiment consisted of three wide row spacings i.e. 1.2 m, 2.4 m (paired row) and 3.6 m (paired row) and three intercrops i.e. soybean, greenpea and onion. With respect to different row spacings, higher number of tillers was recorded in sugarcane at 1.2 m (83429, 64822 and 114076 ha^{-1} respectively) at different crop growth stages. Growing sugarcane at 1.2 m spacing recorded significantly higher plant height (142.22, 180.48 and 206.79 cm respectively) and dry matter production (0.22, 2.65 and 5.77 kg/ m^2) throughout the crop growth. The number of millable canes and cane yield were also significantly higher at 1.2 m (134717 ha^{-1} and 111 t ha^{-1}). Among different intercropping systems, the number of internodes was significantly higher in sugarcane + greenpea (13.93 and 30.91) at 210 DAP and at harvest. The taller sugarcane plants (144.34, 180.62 and 207.42 cm respectively) and higher dry matter production in sugarcane (0.20, 2.72 and 4.64 kg/m^2 respectively) were noticed in greenpea intercropping throughout the plant growth. At 150 DAP, cane diameter and internodal length were significantly higher in sugarcane + greenpea (25.71 mm and 9.10 cm respectively).

KEYWORDS: Sugarcane, Intercropping & Wider Row Spacing

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Original Article

INTRODUCTION

Sugarcane (*Saccharum* spp. hybrid complex) is an important commercial crop as 78 per cent of world sugar is produced from sugarcane. India ranks second, after Brazil, in area and production of sugarcane. The area occupied in the country during 2015-16 is 4.95 million ha with the production of 305.25 million tonnes and productivity of 71.1 t ha^{-1} respectively (Anon., 2016). In India, Karnataka stands 3rd in cane production next to Uttar Pradesh and Maharashtra states and 2nd with respect to sugar recovery after Maharashtra. In Karnataka, sugarcane is cultivated in 4,50,000 ha with the production of 38.48 million tonnes and a productivity of 85.5 t ha^{-1} during 2015-16 season. The total cane crushed in the state during 2015-16 was 37.72 million tonnes. Compared to cane crushed during 2014-15 (44.64 million tonnes), 15.50 per cent crushing was reduced during 2015-16 in Karnataka (Anon., 2016). While farmers feel that they are abandoning sugarcane cultivation due to increase in

cost of cultivation and decrease in profits. In north-west Karnataka, sugarcane is mainly cultivated in 3 districts i.e. Belagavi (6,02,625 ha), Bagalkot (3,04,141 ha) and Bijapur (1,10,987 ha) with the total area of 10.18 lakh ha during 2015-16 season (www.nubesol.co.in).

The major features of sugarcane grown in north-west Karnataka region are medium to lower cane yield and high sugar recovery, acute water shortage during summer months, lower ratoon yields and saline and alkaline soil problems. The climate in this region is warm and dry throughout the year and rainfall is scarce. Bagalkot district receives the lowest rainfall (318 mm) annually in Karnataka. The months of September and December account for about 52 per cent of the total annual rainfall. The Krishna, Ghataprabha and Malaprabha Rivers flow through the region but are non perennial The sugarcane yield in North –west Karnataka region has reduced drastically as there was no water in Malaprabha left bank canal due to failure of rainfall during 2015. Moreover, the farmers could not lift the required water from the borewell as Government is supplying power only for 3-4 hours every day. Successive droughts, delay by factory owners in payment and depleting water sources; these are factors which are prompting traditional sugarcane farmers to abandon growing of sugarcane. Hence to increase the productivity of sugarcane in this region, various agronomic measures that reduce cost of cultivation and improve the cane productivity should be adapted. In this region, most of the farmers have been already growing sugarcane in 1.2 m spacing. In tropical states of India, wide row spacing is become popular in areas with labour shortage. There are scientific studies conducted in research stations, which state that wide row spacing leads to higher yield and net returns and reduced cost of cultivation (Rajula Shanthy and Muthusamy, 2012).

High value and remunerative crops like vegetables, potato, oilseeds and pulses offer great scope for growing as intercrops and in further providing additional income and reducing risks in the long duration crop of sugarcane as well as in improving land use efficiency. Keeping all these aspects in view, the present investigation was carried out to study the effect of agronomic manipulations in sugarcane based cropping system under drip irrigation with three different row spacings (1.2 m, 2.4 m-30 cm-2.4 m and 3.6 m-30 cm-3.6 m) and three intercrops (soybean, greenpea and onion).

MATERIALS AND METHODS

The field experiment was conducted at K. J. Somaiya Institute of Applied Agricultural Research (KIAAR), Sameerwadi, (Taluk: Mudhol, Dist: Bagalkot, Karnataka) which is located at 16˚ 19' N latitude and 75˚ 69' E longitude and at an altitude of 541 m above mean sea level. KIAAR, Sameerwadi comes under northern dry zone of Karnataka (Zone no. 3). During 2013-14 season, the crop received 118.5 mm rainfall in germination and establishment stage (0-35 days). During tillering stage (40-120 DAP), the sugarcane received 195 mm rainfall. There was no rainfall during grand growth stage (120-270 DAP) of the crop. Around 510.9 mm of rainfall occurred during ripening and maturation stage (270- 545 DAP). The total rainfall of 824.4 mm occurred during the entire 18 months crop growth period. The soil of experimental site was medium deep black. The details of experiment with regard to crop, variety, the treatments evaluated, the design adopted and plot size are provided in table (I). Initially the land was ploughed once with tractor drawn mould-board plough and later on worked twice with the cultivator. The land was then harrowed and smoothened to bring the seed bed to a fine tilth. The field was then laid out as described below under different row spacings. The ‘V’ shaped ridges and furrows were formed at spacing of 120 cm, with a furrow depth of 25 cm. In the paired row system, a pair of ‘V’ shaped furrows and ridges were formed at 30 cm spacing between the rows, with a furrow depth of 25 cm and such pairs were spaced at 240 cm and 360 cm apart, giving a paired row spacing of 2.4 m-30 cm-2.4 m cm and 3.6 m-30 cm-3.6 m

On the day of planting cane setts, full doses of phosphorus (75 kg ha^{-1}), potash (190 kg ha^{-1}), zinc sulphate (25 kg ha^{-1}) and ferrous sulphate (25 kg ha^{-1}) along with 10 per cent of the recommended nitrogen (25 kg ha^{-1}) were applied in the form of diammonium phosphate (DAP), muriate of potash (MOP) and urea respectively through fertigation. The sugarcane crop was top dressed with 50, 75 and 100 kg urea per hectare at 6^{th}, 10^{th} and 14^{th} weeks after planting respectively. The recommended dose of fertilizers were applied to the intercrops *viz.* soybean, greenpea, cucumber and watermelon at the time of sowing where as for onion, 50 per cent of the total nitrogen and full doses of phosphorus and potash were applied at sowing in furrows by mixing with the soil and remaining 50 per cent nitrogen was top dressed at 30 days after sowing (DAS). The details are furnished in table (I).

From nine months old sugarcane crop (cv. Co86032) raised for seed multiplication, the two budded setts were prepared carefully. The setts were planted (12/07/2013) in normal method at 1.2 m spacing and in paired row system in 2.4 m and 3.6 m spacing. The seed rate for 1.2 m and 2.4 m spacing was 41667 two eye budded setts per hectare. The seed rate for 3.6 m row spacing is 27778 two eye budded setts per hectare. The setts were pushed down to a depth of 5 cm into the soil. At 4-5 days after planting of sugarcane, the seeds of intercrops *i.e.* soybean, green pea and onion were dibbled in normal method of planting in furrows. The details regarding date of planting, seed rate, etc. are furnished in table (II). The intercrops in sugarcane *viz.*, soybean, greenpea and onion were sown in row proportion of 1:4 in 1.2 m row spacing of sugarcane, 2:7 in 2.4 m row spacing of sugarcane (paired rows) and 2:10 in 3.6 m row spacing of sugarcane (paired rows). Pre-emergence application of herbicide Atrazine at the rate of 2.5 kg per ha was carried out at 3 days after planting (DAP) of sugarcane. Later hand weeding was taken up at 150 DAP after the harvest of all the intercrops. Earthing up was carried out at 150 DAP with the help of power tiller.

Since soybean suppressed sugarcane emergence, gap filling was carried out in sugarcane intercropped with soybean plots. The three months old tissue cultured sugarcane settlings of variety Co86032 were gap filled after the harvest of soybean. The method of irrigation adopted for the experiment was drip irrigation. Before the planting of sugarcane setts, the plots were two times irrigated by flooding. Later, the plots were irrigated three days in a week by drip method. During each time of irrigation, the water was supplied four hours per day. The rate of discharge of water in drip lines was two liters per hour.

Table 1: Details of the Field Experiment

Sl. No.	Particulars	Details	
1	Season	Plant cane (Adsali) July 2013 to December 2014	
2	Farming situation	Drip irrigated	
3	Number of treatments	Plant cane- 12	
4	Replications	Three	
5	Plot size- Gross plot	7.2 m × 14.4 m	
6	Design	Randomized complete block design	
	Row Spacing between Sugarcane	**Net Plot Size In Plant Crop**	**Net Plot Size in Ratoon Crop**
	1.2 m	5.2 m × 7.2 m	5.2 m × 4.8 m
	2.4 m (Paired row)	5.2 m × 9.6 m	5.2 m × 7.2 m
	3.6 m (Paired row)	5.2 m × 7.2 m	5.2 m × 7.2 m

Ratio of Sugarcane and Intercrops in Different Cropping Systems			
Ratio Spacing	**Sugarcane: Soybean**	**Sugarcane: Greenpea**	**Sugarcane: Onion**
1.2 m spacing	100 : 84	100 : 84	100 : 84
2.4 m spacing	100: 75	100: 75	100: 75
3.6 m spacing	67 : 79	67 : 79	67 : 79

Table 2: Details of Variety, Row Arrangement, Date of Sowing/Harvesting, Seed Rate and Fertilizer Application to Sugarcane and Different Intercrops

Sl. No.	Crops	Name of the Variety/Hybrid	Row Proportion of Sugarcane and Intercrops			Date of Planting/ Sowing	Date of Harvesting	Row Spacing for Intercrops	Seed Rate/Ha	Fertilizers (Kg/Ha)		
			1.2 m	2.4 m (Paired row)	3.6 m (Paired row)					N	P_2O_5	K_2O
1	Sugarcane (Plant crop)	CO86032	-	-	-	12/07/2013	06/12/2014	-	8 T/ha (2 eye bud setts)	250	75	190
2	Soybean	JS9305	1:4	2:7	2:10	16/07/2013	22/10/2013	30 cm × 10 cm	62.5 kg	40	80	25
3	Greenpea	AP3	1:4	2:7	2:10	17/07/2013	26/08/2013	30 cm × 10 cm	30 kg	25	50	50
4	Onion	N53	1:4	2:7	2:10	17/07/2013	24/11/2013	30 cm × 10 cm	10 kg	125	50	125

RESULTS AND DISCUSSIONS

Influence of Different Wider Row Spacings on Growth and Yield of Plant Cane

In the present investigation, the sugarcane yield was significantly higher at 1.2 m spacing (111 T ha^{-1}) compared to 2.4 m (89 T ha^{-1}) and 3.6 m (69 T ha^{-1}) row spacings (Table VI). Cane yield is a function of yield attributing characters such as number of millable canes (NMC), single cane weight, internodal length and cane diameter at harvest. In this study, the NMC was significantly higher in sugarcane at 1.2 m spacing (134717 ha^{-1}) compared to 2.4 m (98676 ha^{-1}) and 3.6 m (81114 ha^{-1}) row spacings. This could be attributed to more efficient utilization of moisture, nutrients and solar energy with less inter and intra plant competition in sugarcane grown at 1.2 m spacing. The results are in agreement with Patel *et al*. (2014b) where plant geometry 1.2 m normal row spacing found superior in increasing number of internodes, cane length, number of millable canes and cane yield as compared to 90 cm, 1.5 m and 1.5 m-30 cm-1.5 m row spacing. These results confirm the findings of Patel *et al*., (2014a). Even though the single cane weight did not differ significantly between different row spacings, the yields were lower in paired row spacing compared to single row cane at 1.2 m. This may be due to the production of higher number of tillers in sugarcane at 1.2 m spacing. Cane girth, number of internodes and internodal length per cane didn't reach the level of significance due to various plant geometries. This might be due to varietal characters of specific variety which may not alter generally under favorable conditions. These findings are in agreement with those reported by Patel *et al*. (2014b).

The marked increase in yield at 1.2 m (single row) spacing appears due to better light interception, greater availability of moisture, more aeration to individual setts and increased plant population; better tillering and tiller retention which resulted in taller stalks and increased cane weight at harvest compared to the rest of plant geometries (Patel *et al*., 2014b). In this study, the number of tillers was significantly higher in 1.2 m during 90 DAP, 150 DAP and 210 DAP (85358 ha^{-1}, 64822 ha^{-1} and 114880 ha^{-1}) (Table V). Moreover, in paired row spacing at 2.4 m and 3.6 m, the lesser space was available within the pairs *i.e*. 30 cm. this may be the reason for higher inter plant competition within the paired rows at grand growth stage of sugarcane for utilization of available resources compared to single row planting in 1.2 m spacing. Tiller mortality was also higher at 2.4 m and 3.6 m paired row spacing compared to 1.2 m spacing during 90 – 150 DAP. The research conducted in Australia also found that the close dual rows (50 cm) competed against each other resulting in a lot of dieback and thin stalks. Thin stalks resulted in higher harvesting losses and lower cane weights (up to 10 % lower). Also, when lodging occurred the two rows would lodge in opposite directions making harvesting difficult (Anon., 2008). In

contrast to this, Sarala *et al*. (2014) noticed the higher cane yield in paired row planting (105-75-105 cm) of sugarcane. This was mainly because of the higher number of millable canes and longer canes under this treatment. The wider spacing available between two sets of paired rows (75 cm) could have permitted better light interception under paired row spacing and also would have facilitated good earthing-up to minimize lodging. This suggested that, in our study, the interspace/ dual row ratio (30 cm) was not ideal. Tiller growth in sugarcane constitutes the major sink for photosynthate. The tiller population supports the leaf canopy that generates the potential source of photosynthate (Singels and Smit, 2002).

In the present investigation, the increased cane yield at 1.2 m spacing can be traced back to the significant increase in the accumulation of dry matter in the stem and leaves. In this study, by analyzing the data on sugarcane dry matter at various stages, it is clear that sugarcane grown at 1.2 m spacing (0.22, 2.65 and 5.77 kg/m^2 at 150, 210 DAP and at harvest) produced more dry weight compared to sugarcane at 2.4 m (0.15, 1.68 and 3.78 kg/m^2 at 150, 210 DAP and at harvest) and 3.6 m (0.10, 1.51 and 3.11 kg/m^2 at 150, 210 DAP and at harvest). This may be because of higher photosynthetic activity in sugarcane at 1.2 m spacing compared to other spacings. Photosynthetic rates influence dry matter accumulation and crop growth rate (Hunsigi, 2001). The results are in agreement with Patel *et al*. (2014a). Analysis of chlorophyll content is important for evaluating the health or integrity of the internal apparatus during photosynthetic process within a leaf (Clark *et al*., 2000). The dry matter accumulation is the resultant of plant height. Various plant geometries significantly influenced total plant height. Planting of sugarcane setts at distance of 1.2 m recorded significantly higher total plant height at 150 DAP (142.22 cm) and at harvest (182.34 cm) than other plant geometries (Table IV). Increased plant height at 150 DAP and at harvest may be due to better development of growth parameters. Patel *et al*. (2014a) also noted significant differences in total plant height of sugarcane with various plant geometries. The lower plant height at 2.4 m and 3.6 m paired row spacing may also be due to bending of plants for utilization of solar radiation in wider spacing.

Influence of different Intercropping Systems on Growth and Yield of Sugarcane

The three intercrops (soybean, greenpea and onion) had almost different growth patterns and canopies. This being the situation, soybean was quite fast in growth as well as covering the ground cover much early, thus inhibiting the emergence of sugarcane and further restricting the growth compared to other two intercrops. Due to this, large number of gaps was noticed and was filled by transplanting 90 days old sugarcane settlings after the harvest of soybean. By the end of the crop growth, these settlings had made their growth as compared to the other two intercrops (greenpea and onion) thus producing similar yields in all the treatments. Probably had there been lesser number of rows of soybean, the impact on the growth of sugarcane would not have been as severe as noticed in the present experiment. Another reason due to which sugarcane in soybean could compensate its growth because of 400 days which it got for the growth (Totally 545 days was the growth period).

With reference to different intercropping systems, there was no significant difference between sugarcane yields, NMC and single cane weight of sole sugarcane and sugarcane grown with different intercrops (soybean, greenpea and onion) (Table VI). However, intercropping with greenpea recorded higher cane yield (96 t/ha) compared to sugarcane intercropped with onion (89 T/ha) and soybean (85 T/ha). So it can be concluded that the intercrops onion and greenpea did not affect the growth and yield of sugarcane. This might be possible due to non-exhaustive and dwarf nature of the intercrop (onion) and residual effect of the additional fertilizers as well as cultural practices and irrigation applied to intercrops grown with sugarcane (Hossain *et al.*, 2003). Compared to other crops, onion exerted least detrimental effect on

the emergence, tiller, millable cane and yield of sugarcane (Hossain, 1984). The results are also in conformity with Saini *et al*., (2003) where the intercropping of vegetable pea did not affect the cane yield adversely rather there was slight improvement over the pure cane. But in case of cane + soybean intercropping, soybean suppressed the growth of sugarcane due to its high canopy coverage. This resulted in low emergence of sugarcane. But after the harvest of soybean at 110 DAP, the sugarcane plot was gap-filled with 90 days old settlings. In the present study, the plant cane was harvested at 18 months. So the transplanted settlings attained better growth and hence there was no significant difference between yield, NMC and single cane weight of sole sugarcane and sugarcane grown with soybean.

The yield in sugarcane is closely associated with number of internodes, internodal length and cane diameter. Among different inter-cropping systems, cane diameter and internodal length were significantly higher in sugarcane + greenpea (25.71 mm and 9.10 cm, respectively) at 150 DAP. The number of internodes was significantly higher in sugarcane + greenpea at 210 DAP (13.93) and at harvest (30.91) (Table III). It may be due to the favorable effect of greenpea on sugarcane. The low competition with main crop and its nitrogen fixing capacity could be the factor responsible for this behavior. The results are in accordance with Hossain *et al.*, (2003) and Saini *et al.*, (2003). The number of tillers was significantly higher in sugarcane + greenpea at 90, 150 and 210 DAP (94821, 57281 and 100501, respectively) (Table IV). This may be attributed to more amount of available nitrogen contributed by the vegetable pea at later stages of sugarcane growth. The results are in accordance with Varghese *et al.* (2006). The biomass of greenpea was incorporated in sugarcane field after the harvest. This may have supplied additional nitrogen to sugarcane. But in case of sugarcane + soybean, the tiller population was lower compared to sugarcane with onion and greenpea and sole sugarcane at 90 DAP. This may be because of soybean variety JS9035 which influenced early growth of the cane. The soybean attained vigorous growth due to competition for limited resources. This resulted in lower light transmission for sugarcane settlings. In the present study, soybean planting in higher ratios might have reduced the sugarcane tillering at the co-growth stage. When soybean was in the flowering stage, sugarcane was still in the seedling and tillering stage. The soybean canopy at 30 DAS fully covered the space in sugarcane row. It decreased the radiation intercepted by sugarcane, hence reducing the number of total tillers in the intercropping system. The results are in agreement with Ayele *et al*. (2014). But after transplanting of 90 days old settlings at 120 DAP, the tillering was initiated. Hence the number of tillers was significantly lower in sugarcane + soybean during 150 and 210 DAP.

By examining the data on dry matter production of sugarcane at various stages of inter-cropping systems, we can conclude that sugarcane + greenpea recorded significantly higher values at 150 and 210 DAP (0.20 and 2.72 kg/m^2, respectively) (Table V). This may be because of higher number of internodes and higher plant height of sugarcane intercropped with greenpea. Taller canes in case of cane intercropped with greenpea at 150, 210 DAP and at harvest (138.52, 177.07 and 207.42 cm, respectively) show the better development of growth parameters in sugarcane intercropped with greenpea. Whereas in case of sugarcane + soybean, the cane height was significantly lower compared to other treatments. The reason behind this was, the sugarcane settlings gap-filled at 120 DAP were younger compared to the sugarcane grown in other treatments.

Effect of different Row Spacings and Intercropping Systems on Juice Quality of Sugarcane

Our study demonstrated that the various quality parameters of sugarcane *i.e.* brix (%), pol (%), purity and CCS (%) were not affected by different row spacings. Since the rate of fertilizers applied was equal in all the spacings, the quality of sugarcane did not differ significantly. The results are in conformity with the findings of Sarala *et al.* (2012) and

Chakrawal and Kumar (2014). The current study demonstrated that sugarcane intercropping with soybean, greenpea and onion did not affect significantly on sugarcane juice quality (Table VII). The results are in line with Sarala *et al*. (2012). Mahadevaswamy and Martin (2002) also reported that levels of row spacing or intercropping of onion in the systems did not affect the juice quality of cane. Similarly, intercropping of different crops did not show any significant adverse effect on cane quality in terms of Pol per cent juice and commercial cane sugar (CCS %). This might be due to the fact that quality parameters are inherent character of the crop and variety (Kumar *et al.*, 2015b).

CONCLUSIONS

Thus by considering the effect of different row spacings and intercropping systems on growth, yield and quality parameters of plant cane, it can be concluded that sugarcane at 1.2 m + greenpea and sugarcane at 1.2 m + onion are the best intercropping systems compared to other systems.

REFERENCES

1. *Anonymous, 2008, SRDC Grower Group Innovation Project final report Implementation of a 2M farming system. Sugar Research Australia Ltd., eLibrary, http://elibrary.sugarresearch.com.au/, pp. 4.*
2. *Anonymous, 2016, Sugar Statistics. Cooperative Sugar, 48 (4):32-74.*
3. *Ayele, N., Getaneh, A., Mekuanent, Y., Mengistu, L., Bikila, M. and Hagos, H. (2014). Effect of different planting methods of soybean in an intercropping with sugarcane at Wonji-Shoa sugar estate. J. Agri. Natural Resources Sci., 1(3), 180-185.*
4. *Chakrawal, D. & Kumar, N. (2014) Physio- agronomic analysis of sugarcane (Saccharum spp. hybrid complex) varieties under different planting geometry. Indian J. Sugarcane Technol., 29(02), 67-71.*
5. *Clark, A. J., Landolt, W., Bucher, J. B. and Strasser, R. J. (2000) Beech (Fagus sylvatica) response to ozone exposure assessed with a chlorophyll fluorescence performance index. Environ. Pollution, 109, 501-507.*
6. *Hossain, A. (1984) Intercropping with reference to sugarcane cultivation in Bangladesh. M.Sc. (T.A.D.) Thesis, Univ. Reading, England. [Cited in: Alam, M. J., Rahman, M. M., Sarkar, M. A. R., Rahman, M. K., Islam, A. K. M. R., Sohel, M. A. T., Uddin, M. J. and Habib, M. K. (2015) Productivity of lentil-mungbean sequential intercropping in paired row sugarcane. Int. J. Sustain. Crop Production, 10 (1), 1-10].*
7. *Hossain, G. M. A., Bokhtiar, S. M., Paul, S. K. and Anam, M. R. (2003) Intercropping of sugarcane with onion and potato followed by sesame in paired row system. Pakistan J. Agron., 2(2), 85-91.*
8. *Hunsigi, G., 2001, Sugarcane in Agriculture and Industry. Prism Books Pvt. Ltd., Bengalooru, Karnataka.*
9. *Kumar, R., Singh, J. and Uppal, S. K., 2015b, Intercropping of medicinal and high value crops in autumn sugarcane (Saccharum spp. hybrid) for higher productivity and profitability. Indian J. Agron., 60 (1): 61-64.*
10. *Mahadevaswamy, M. & Martin, G. J. (2002) Production potential of wide row sugarcane intercropped with aggregatum onion (Allium cepa) under different row ratios, fertilizer levels and population densities. Indian J. Agron., 47 (3), 361-366.*
11. *Patel, D., Raj, V. C., Tandel, B., Patel, B., Patel D. U. and Surve, V. (2014a) Influence of planting distance and variety on growth of sugarcane and weed population under mechanization. J. Intl. Academic Res. Multidisciplinary, 2 (6), 34-41.*
12. *Patel, D., Raj, V. C., Tandel, B., Patel, B., Patil, P., Patel, A. M. and Patel D. U. (2014b) Sugarcane yield and nutrient uptake under plant geometry and variety in relation to mechanization. The Bioscan, 9(4), 1445-1448.*
13. *Rajula shanthy, T. & Muthusamy, G. R. (2012) Wider row spacing in sugarcane : A socio-economic performance analysis. Sugar Tech, 14 (2), 126-133.*

14. *Sagoo, A. G., Khan, E. A., Tullah, H. H., Khan, M. A. and Ahmad, H. K. (2010) Morphological response of autumn planted sugarcane to available soil moisture depletion and planting geometry on different soils under arid conditions. Sarhad J. Agric., 26 (2), 187-194.*

15. *Saini, L. K., Singh, M. and Kapur, M. L. (2003) Relative profitability of intercropping vegetable crops in autumn planted sugarcane. Sugar Tech, 5 (l&2), 95 – 97.*

16. *Sarala, N. V., Subba Rao, M., Hemanth Kumar, M. and Nagamadhuri, K. V. (2014) Response of sugarcane to plant geometry and irrigation methods in southern agro-climatic zone of Andhra Pradesh. J. Sugarcane Res., 4 (1), 86-90.*

17. *Singels, A. & Smit, M. A. (2002) The effect of row spacing on an irrigated plant crop of sugarcane variety NCO376. Proc. 76th South African Sugarcane Techno. Ass., South Africa. pp. 94-105.*

18. *Varghese, K., Massey, N., Sahotra, R. and Ghosh, G. (2006) Economic evaluation of different companion crops in autumn planted sugarcane (Saccharum Officinarum). Agric. Sci. Digest, 26 (1), 77-78.*

19. *www.nubesol.co.in*

20. *Zhou, M. (2005) Potential of using physiological parameters to enhance sugarcane selection. Proc. 79th South African Sugarcane Technologists' Ass., South Africa, pp. 521-529.*

Table 3: Number of Internodes and Internodal Length (Cm) in Sugarcane at 150, 210 DAP and at Harvest as Influenced by Different Row Spacings and Intercrops

Spacing / Intercrop	1.2 m (1:4)	2.4 m (2:7)	3.6 m (2:10)	Mean	1.2 m (1:4)	2.4 m (2:7)	3.6 m (2:10)	Mean	1.2 m (1:4)	2.4 m (2:7)	3.6 m (2:10)	Mean	1.2 m (1:4)	2.4 m (2:7)	3.6 m (2:10)	Mean	1.2 m (1:4)	2.4 m (2:7)	3.6 m (2:10)	Mean	1.2 m (1:4)	2.4 m (2:7)	3.6 m (2:10)	Mean	1.2 m (1:4)	2.4 m (2:7)	3.6 m (2:10)	Mean
	Number of Internodes in Sugarcane												Internodal Length (cm) In Sugarcane															
	150 DAP				210 DAP				At harvest				150 DAP				210 DAP				At harvest							
Sugarcane+ Soybean	5.73	4.93	4.20	**4.96**	9.73	7.80	9.93	**9.16**	26.40	22.33	25.93	**24.89**	6.20	6.08	5.61	**5.96**	7.06	8.25	6.15	**7.15**	8.90	9.47	7.67	**8.68**				
Sugarcane+ Greenpea	3.87	4.53	5.87	**4.76**	15.40	13.13	13.27	**13.93**	33.07	29.07	30.60	**30.91**	8.97	9.70	8.63	**9.10**	6.33	6.71	7.61	**6.89**	8.33	8.43	8.43	**8.40**				
Sugarcane+ Onion	4.27	4.93	4.73	**4.64**	11.87	12.73	13.80	**12.80**	27.80	30.27	30.27	**29.44**	7.59	8.06	8.01	**7.89**	6.64	7.13	5.47	**6.41**	8.43	8.63	7.23	**8.10**				
Sole Sugarcane	3.93	4.80	**6.00**	**4.91**	14.40	13.27	12.93	**13.53**	32.13	30.73	29.07	**30.64**	5.07	8.15	7.65	**6.96**	7.09	5.93	6.92	**6.65**	8.47	7.70	8.30	**8.16**				
Mean	**4.45**	**4.80**	**5.20**		**12.85**	**11.73**	**12.48**		**29.85**	**28.10**	**28.97**		**6.96**	**8.00**	**7.47**		**6.78**	**7.01**	**6.54**		**8.53**	**8.56**	**7.91**					
	SEm±	CD at 5 %	Result		SEm±	CD at 5 %	Result		SEm±	CD at 5 %	Result		SEm±	CD at 5 %	Result		SEm±	CD at 5 %	Result		SEm ±	CD at 5 %	Result					
Spacing			NS				NS		0.62	1.81	NS				NS				NS				NS					
Intercrops			NS		0.48	1.40	S		0.71	2.09	S		0.41	1.21	S				NS				NS					
S X I	0.54	1.57	S				NS		1.23	3.62	NS				NS		0.55	1.60	S				NS					

Table 4: Plant Height (Cm) and Dry Matter Production in Sugarcane (Kg/M2 Area) at 150, 210 DAP and at Harvest as Influenced by Different Row Spacings and Intercrops

Spacing / Intercrop	1.2 m (1:4)	2.4 m (2:7)	3.6 m (2:10)	Mean	1.2 m (1:4)	2.4 m (2:7)	3.6 m (2:10)	Mean	1.2 m (1:4)	2.4 m (2:7)	3.6 m (2:10)	Mean	1.2 m (1:4)	2.4 m (2:7)	3.6 m (2:10)	Mean	1.2 m (1:4)	2.4 m (2:7)	3.6 m (2:10)	Mean	1.2 m (1:4)	2.4 m (2:7)	3.6 m (2:10)	Mean
	Plant Height (cm) in Sugarcane												Dry Matter Production in Sugarcane (kg/m²)											
	150 DAP				210 DAP				At harvest				150 DAP (Stem + Leaves)				210 DAP (Stem + Leaves)				At Harvest (Stem)			
Sugarcane + Soybean	129.69	110.53	107.63	**115.95**	173.67	150.47	143.80	**155.98**	199.57	175.52	171.95	**182.34**	0.06	0.04	0.06	**0.06**	0.99	0.91	0.85	**0.91**	5.04	4.13	2.47	**3.88**
Sugarcane + Greenpea	153.32	141.19	138.52	**144.34**	183.53	181.27	177.07	**180.62**	216.99	204.38	200.90	**207.42**	**0.29**	0.20	0.10	**0.20**	**3.12**	2.47	2.59	**2.72**	6.06	3.72	4.14	**4.64**
Sugarcane + Onion	138.79	134.78	134.62	**136.06**	180.67	187.47	162.33	**176.82**	203.73	210.39	187.61	**200.58**	0.25	0.17	0.12	**0.18**	2.59	1.54	1.07	**1.73**	6.08	3.11	3.04	**4.08**
Sole Sugarcane	147.07	145.07	138.16	**143.43**	184.07	179.80	174.93	**179.60**	206.86	202.25	191.83	**200.31**	**0.29**	0.18	0.12	**0.20**	**3.93**	1.81	1.52	**2.42**	5.88	4.14	2.81	**4.28**
Mean	**142.22**	**132.89**	**129.73**		**180.48**	**174.75**	**164.53**		**206.79**	**198.14**	**188.07**		**0.22**	**0.15**	**0.10**		**2.65**	**1.68**	**1.51**		**5.77**	**3.78**	**3.11**	
	SEm±	CD at 5%	Result		SEm±	CD at 5%	Result		SEm±	CD at 5%	Result		SEm ±	CD at 5%	Result		SEm ±	CD at 5%	Result		SEm±	CD at 5%	Result	
Spacing	3.09	9.05	S				NS		4.77	14.00	S		0.01	0.03	S		0.10	0.30	S		0.20	0.59	S	
Intercrops	3.56	10.46	S		5.61	16.45	S		5.51	16.16	S		0.01	0.03	S		0.12	0.35	S				NS	
S X I			NS				NS		9.55	27.99	NS		0.02	0.05	S		0.21	0.61	S				NS	

Table 5: Cane Diameter (Mm) and Number of Tillers at Different Growth Stages of Sugarcane as Influenced by Different Row Spacings and Intercrops

Spacing / Intercrop	1.2 m (1:4)	2.4 m (2:7)	3.6 m (2:10)	Mean	1.2 m (1:4)	2.4 m (2:7)	3.6 m (2:10)	Mean	1.2 m (1:4)	2.4 m (2:7)	3.6 m (2:10)	Mean	1.2 m (1:4)	2.4 m (2:7)	3.6 m (2:10)	Mean	1.2 m (1:4)	2.4 m (2:7)	3.6 m (2:10)	Mean	1.2 m (1:4)	2.4 m (2:7)	3.6 m (2:10)	Mean	1.2 m (1:4)	2.4 m (2:7)	3.6 m (2:10)	Mean
	Cane Diameter (mm) in Sugarcane												Number of Tillers in Sugarcane															
	150 DAP				210 DAP				At harvest				90 DAP				150 DAP				210 DAP				At harvest			
Sugarcane + Soybean	19.42	21.35	19.41	**20.06**	26.03	25.07	25.49	**25.53**	27.10	25.60	26.03	**26.24**	34336	19869	13632	**22612**	22666	20833	18100	**20533**	68897	63625	55394	**62639**	127353	102526	68737	**99539**
Sugarcane + Greenpea	25.30	25.71	26.13	**25.71**	27.84	25.81	27.30	**26.98**	28.43	26.73	27.80	**27.66**	99536	**112268**	72659	**94821**	**92753**	47003	32086	**57281**	**131365**	87705	82433	**100501**	140688	94296	91145	**108710**
Sugarcane + Onion	24.17	25.13	24.29	**24.53**	24.49	26.98	25.25	**25.58**	25.83	27.50	26.40	**26.58**	87962	92592	62242	**80932**	73173	45332	27842	**48782**	130979	80632	73720	**95110**	140268	89699	81597	**103854**
Sole Sugarcane	25.47	25.53	25.38	**25.46**	26.04	26.11	26.04	**26.06**	26.97	25.83	27.20	**26.67**	111882	96643	69315	**92613**	70698	43467	28485	**47550**	125064	91113	75553	**97243**	130561	108185	82979	**107242**
Mean	**23.59**	**24.43**	**23.80**		**26.10**	**25.99**	**26.02**		**27.08**	**26.42**	**26.86**		**83429**	**80343**	**54462**		**64822**	**39159**	**26628**		**114076**	**80769**	**71775**		**134717**	**98676**	**81114**	
	SEm±	CD (p=0.05)	Result		SEm±	CD (p=0.05)	Result		SEm±	CD (p=0.05)	Result		SEm±	CD at 5%	Result		SEm±	CD at 5%	Result		SEm±	CD at 5%	Result		SEm±	CD at 5%	Result	
Spacing			NS				NS				NS		2164	6347	S		1562	4581	S		3071	9006	S		4178	12255	S	
Intercrops	0.87	2.55	S				NS				NS		2499	7328	S		1804	5290	S		3546	10399	S				NS	
S X I			NS				NS				NS		4328	12693	S		3124	9162	S		6141	18012	S				NS	

Table 6: Sugarcane Yield (T/Ha), Number of Millable Canes (/Ha) and Single Cane Weight (Kg) at Harvest as Influenced by Different Row Spacings and Intercrops

Spacing / Intercrop	1.2 m (1:4)	2.4 m (2:7)	3.6 m (2:10)	Mean	1.2 m (1:4)	2.4 m (2:7)	3.6 m (2:10)	Mean	1.2 m (1:4)	2.4 m (2:7)	3.6 m (2:10)	Mean
	Sugarcane Yield (t/ha)				Number of Millable Canes/ha				Single Cane Weight at Harvest (kg)			
Sugarcane + Soybean	109	89	56	**85**	127353	102526	68737	**99539**	1.00	1.00	0.92	0.97
Sugarcane + Greenpea	114	93	83	**96**	140688	94296	91145	**108710**	0.92	1.08	1.08	1.03
Sugarcane + Onion	110	82	74	**89**	140268	89699	81597	**103854**	0.92	1.00	1.00	0.97
Sole Sugarcane	111	94	64	**90**	130561	108185	82979	**107242**	1.00	0.92	1.08	1.00
Mean	**111**	**89**	**69**		**134717**	**98676**	**81114**		0.96	1.00	1.02	
	SEm±	CD (p=0.05)	Result		SEm±	CD (p=0.05)	Result		SEm±	CD (p=0.05)	Result	
Spacing	3.52	10.34	S		4178	12255	S				NS	
Intercrops			NS				NS				NS	
S X I			NS				NS				NS	

Table 7: Influence of Different Row Spacings and Intercrops on Quality Parameters of Sugarcane at Harvest

Spacing / Intercrop	1.2 m (1:4)	2.4 m (2:7)	3.6 m (2:10)	Mean	1.2 m (1:4)	2.4 m (2:7)	3.6 m (2:10)	Mean	1.2 m (1:4)	2.4 m (2:7)	3.6 m (2:10)	Mean	1.2 m (1:4)	2.4 m (2:7)	3.6 m (2:10)	Mean
	Brix (%)				Pol (%)				Purity (%)				Commercial Cane Sugar Percentage (CCS %)			
Sugarcane + Soybean	21.36	20.98	21.54	**21.29**	19.13	18.84	19.28	**19.08**	89.52	89.79	89.50	**89.61**	13.31	13.13	13.41	**13.29**
Sugarcane + Greenpea	21.45	21.48	21.81	**21.58**	19.23	19.22	19.71	**19.39**	89.63	89.49	90.36	**89.83**	13.39	13.37	13.77	**13.51**
Sugarcane + Onion	21.24	21.47	21.97	**21.56**	19.01	19.14	19.78	**19.31**	89.49	89.12	90.00	**89.53**	13.22	13.29	13.80	**13.44**
Sole Sugarcane	21.45	21.71	22.07	**21.74**	19.31	19.49	19.93	**19.58**	92.83	89.77	90.30	**90.97**	13.48	13.58	13.92	**13.66**
Mean	**21.37**	**21.41**	**21.85**		**19.17**	**19.17**	**19.68**		**90.37**	**89.54**	**90.04**		**13.35**	**13.34**	**13.73**	
	SEm±	CD (p=0.05)	Result		SEm ±	CD (p=0.05)	Result		SEm±	CD (p=0.05)	Result		SEm±	CD (p=0.05)	Result	
Spacing			NS				NS				NS				NS	
Intercrops			NS				NS				NS				NS	
S X I			NS				NS				NS				NS	